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ABSTRACT

Based on the concept that teachers can help students become better learners, mastery learning involves the identification of specific segments of learning and then mastery of them by individual students. Mastery learning provides a structure for teaching that includes class instruction followed by small group work. It is a group-based approach to individualized instruction in which students often can learn cooperatively with their classmates. Mastery learning is a way to individualize instruction within the framework of a traditional group instruction classroom setting. The mastery learning instructional model described in this publication involves four steps: (1) teaching the unit to the class; (2) giving a test to check students' learning at the unit's end and then assessing mastery of subject matter; (3) giving either enrichment activities or corrective activities to students as required; and (4) giving a second test to measure mastery again. This handbook also provides sample mastery learning units and answers to frequently asked questions about the mastery learning steps. (JMK)

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CENTERING ON

MASTERY LEARNING IN YOUR CLASSROOM

A HANDBOOK FOR AN APPROACH TO AN ALTERNATIVE LEARNING STRATEGY

ANITA CIMINO
Teacher Center Specialist

U.S. DEPARTMENT OF EDUCATION
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FOREWORD

The New York City Teacher Centers Consortium is pleased to present a publication dealing with a topic of interest to teachers. These materials are being disseminated in response to the expressed needs of teachers who wish to incorporate an alternative approach to learning in their classrooms.

Mastery Learning In Your Classroom describes strategies for teachers who wish to design Mastery Learning units for whole class lessons with a follow-up for small group instruction. The strategies are presented in a format that provides teachers with techniques for planning instruction, assessing learning, and managing corrective and enrichment activities in their classrooms.

The approach that is described is one of many that can be used to motivate students and improve learning. It is meant to be a companion piece to other Mastery Learning publications.

We encourage teachers to look beyond these materials and select the approach that best serves their own and their students' individual needs.

Myrna Cooper, Director
New York City Teacher Centers Consortium

INTRODUCTION

This booklet has been written because many teachers have requested information regarding Mastery Learning, an alternative approach to learning. What is Mastery Learning? How can I use this approach in my classroom? How can Mastery Learning motivate my students? These questions have been frequently asked by teachers who are interested in trying Mastery Learning in their classrooms.

If you are interested in an alternative approach to learning, this booklet will provide some strategies and resources to get you started. Included are many teacher-tested suggestions that present a workable model for you to implement in your classroom. The ideas can be adapted to elementary, junior high school and high school levels.

TABLE OF CONTENTS

FOREWORD	i
INTRODUCTION	ii
TABLE OF CONTENTS	iii
ABOUT THE AUTHOR	iv
ACKNOWLEDGMENTS	v
WHAT IS MASTERY LEARNING?	1
DO I NEED TO CHANGE MY TEACHING STYLE WHEN USING THE MASTERY LEARNING APPROACH?	2
HOW DO I PLAN FOR MASTERY LEARNING?	3
AFTER I PLAN, HOW DO I USE MASTERY LEARNING STRATEGIES IN MY CLASSROOM?	7
MASTERY LEARNING INSTRUCTIONAL MODEL	8
HOW DO I ADAPT INSTRUCTION FOR "FAST" AND "SLOW" LEARNERS?	9
WHY DO I TEACH THE LESSONS TO THE ENTIRE CLASS?	10
HOW DO THE CORRECTIVES HELP SLOW LEARNERS?	11
WHAT DO STUDENTS WHO ACHIEVE MASTERY DO DURING THIS TIME?	13
WHAT CLASSROOM MANAGEMENT STRATEGIES ARE EFFECTIVE WHEN WORKING WITH INDIVIDUAL STUDENTS AND SMALL GROUPS?	14
HOW DO I DETERMINE STUDENTS' LEARNING FOLLOWING THE USE OF CORRECTIVES?	16
HOW DO I MOTIVATE STUDENTS TO STUDY FOR FORMATIVE TEST A IF THEY KNOW THAT THEY HAVE A SECOND CHANCE?	17
WHAT ABOUT STUDENTS WHO STILL DO NOT 'GET' MASTERY AFTER FORMATIVE TEST B?	19
HOW CAN I ENCOURAGE PARENTAL SUPPORT OF THE PROGRAM?	20
TABLE OF SPECIFICATIONS: A SUGGESTED MASTERY LEARNING PLAN	21
SAMPLE MASTERY LEARNING UNITS	26
SAMPLE UNIT: USE AND MEANING OF FRACTIONAL NUMBERS	27
SAMPLE UNIT: ANCIENT EGYPTIAN NUMERATION SYSTEM	39
REFERENCES	51

ABOUT THE AUTHOR

Anita Cimino is a Teacher Center Specialist for the New York City Teacher Centers Consortium. Since working with the Teacher Center project, she has served as a Mastery Learning consultant and presented workshops and materials to teachers and teacher-trainers, on all grade levels, who are interested in this approach.

Prior to becoming a Teacher Center Specialist, she worked as a classroom teacher. Anita Cimino is currently instructing graduate students in a Mastery Learning course under the combined auspices of Brooklyn College and the New York City Teacher Centers Consortium.

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Anita Cimino

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WHAT IS MASTERY LEARNING?

Mastery Learning involves the identification of specific segments of learning and then the mastery of them by individual students.

Mastery Learning provides a structure for teaching that includes whole group (class) instruction followed by small group work.

It is a group-based approach to individualized instruction in which students often can learn cooperatively with their classmates.

It is a way to individualize instruction within the framework of a traditional group instruction classroom setting.

Mastery Learning, as developed by Dr. Benjamin Bloom, is based on the concept that teachers can help students become better learners.

DO I NEED TO CHANGE MY TEACHING STYLE WHEN USING THE MASTERY LEARNING APPROACH?

No, teach as you usually would. Mastery Learning incorporates many of the good teaching practices that you may already use. Mastery Learning provides a workable structure for improving learning and instruction. It involves planning and time for:

- preparing the unit
- providing for students who need additional work
- marking tests
- keeping your records

HOW DO I PLAN FOR MASTERY LEARNING?

Decide what your instructional objectives are for a unit that you will teach in one to three weeks.

Put the instructional objectives in your plan (see Table of Specifications: A Suggested Mastery Learning Plan)

Instructional objectives may be found in your:

- textbook - teachers' edition
- curriculum guide
- curriculum bulletin

Plan a short test: Formative Test A

Formative Test A will ascertain students' learning at the end of the unit:

- Plan for 20-25 test items
- Group test items together
  - group according to type (e.g., matching, multiple choice, essay, etc.)
  - group test items according to instructional objectives (items that test literal recall such as terms and facts are grouped together whereas items that test translation and application are grouped together. Items that test the students' abilities to analyze, synthesize and evaluate are generally at the end of the test).

Plan the mastery goal

Determine what score will constitute "mastery" for this unit of study. Many Mastery Learning teachers establish 80% as the mastery goal, however you are the best judge of what constitutes mastery of the unit. The goal that you set should provide a challenge. Dr. Thomas R. Guskey, of the University of Kentucky, suggests that while there is some flexibility in determining the mastery level it should not be so low that mastery is not tested or so high that it frustrates the student.

The mastery level should be:

- understood by students
- realistic
- agreed on beforehand
- a reflection of the learnings of the objectives of the unit (there are no "surprise" items that haven't been covered in the unit)

Plan a second test: Formative Test B

Formative test B is parallel to formative test A in:

- test format
- difficulty
- test items
- wording
- number of test items

Mastery in formative test B is established at the same level as mastery in formative test A. That is, if mastery in formative test A is 80%, then mastery in the second formative test is the same.

Summative Tests

Teachers in the junior high school and high school use test items from several units of formative tests A and B to form a pool of items for a mid-term or final examination. This is a summative test and the purpose is to test retention of the subject.

For a detailed description of test development techniques refer to:

Block, James H. and Anderson, Lorin W.
Mastery Learning in Classroom Instruction.
New York: Macmillan Publishing Co., Inc., 1975.

Plan for:

- Correctives - These are additional learning experiences for students who have not achieved mastery on formative test A.

Plan for:

- Enrichment Activities - These are extended learning experiences for students who have achieved mastery on formative test A.

What unit are you presently teaching? List 3 corrective and enrichment activities that can be used with students following the unit test.

Correctives:

1. _____

2. _____

3. _____

Enrichment Activities:

1. _____

2. _____

3. _____

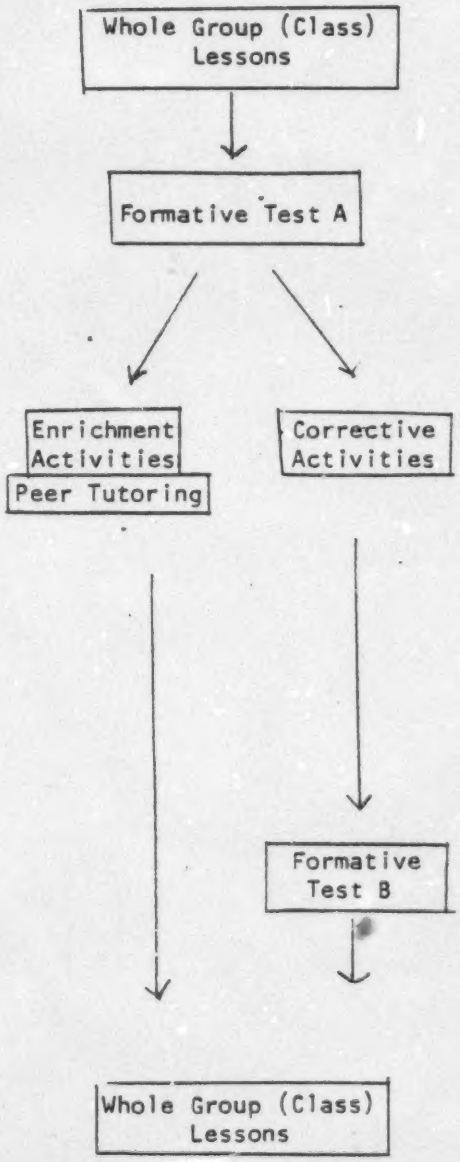
AFTER I PLAN, HOW DO I USE MASTERY LEARNING STRATEGIES IN MY CLASSROOM?

(see: Mastery Learning Instructional Model)

- Introduce Mastery Learning to your class as a program designed to improve learning. The following statements have been used by teachers to motivate students:
  - "All students in this class can be better learners."
  - "When you understand what was taught, and do well on the test, that is 'mastery'."
  - "We will work together to get mastery."
  - "If you don't get mastery on the first test, it may be that you need additional work. You will get help and a second chance."

- You have already identified and planned for a small unit of study that you will teach. It may take from one to three weeks to teach this small segment of learning. The key words are "small segment of learning." Small segments of learning are easier to check, diagnose and remediate. If the learning does not take place, the problems can be checked early and correctives can be given to the student immediately.
- Refer to the instructional objectives in your plan. (see Table of Specifications: A Suggested Mastery Learning Plan)
- Teach the whole group lessons for the unit as you usually would.

MASTERY LEARNING INSTRUCTIONAL MODEL



Step I

- Teach the unit (small segment of instruction) to the entire class.

Step II

- Give a short test to check learning at the end of the unit. Assess mastery of subject matter.

Step III

- Give enrichment activities to students who get "mastery" on the test.
- Some students may help others (peer tutors)
- Give correctives to students who may need:
  - more time
  - additional instruction
  - varied instruction

Step IV

- Give a second test that is parallel in test items.

• • • • •

Now go on to the next unit.

HOW DO I ADAPT INSTRUCTION FOR "FAST" AND "SLOW" LEARNERS?

After the material in the small segment of learning is covered, give a short test or quiz.

This is Formative Test A. This test has a meaning that is different from the usual test.

It represents a check on instruction up to that point. Instead of signifying the end of instruction, it provides precise feedback to both you and the students.

The test is based on subject matter that was covered and identifies which concepts have been learned well or "mastered" and which have not.

Again, you are the best judge of what determines "mastery."

WHY DO I TEACH THE LESSONS TO THE ENTIRE CLASS?

- Mastery Learning is based on the assumption that, given the proper instruction and the time to learn, all children can improve their learning potential and, in fact, be better learners.

- Rather than planning for "good" learners or "bad" learners, plan for "fast" and "slow" learners.

- Plan to give time, as needed, to students who have not achieved mastery of the subject matter following the initial teaching to the entire class.

HOW DO THE CORRECTIVES HELP SLOW LEARNERS?

Start with the assumption that many students may need an additional "push" and can learn better if, when needed, they are given:

- Additional Motivation - A Second Chance

  Some suggested approaches:

  - "You can learn better if we work on this together."
  - "What was the problem?" (the student may not have studied sufficiently or understood the concept during the initial teaching)
  - "You may need more time to study."

  The student may need:

  - additional time
  - additional instruction
  - instruction different from the method used with the class
  - instruction in the student's preferred learning modality (ies)

    Involve students in a way that is different. For example, if you are testing recall of a term or fact and you taught the class using direct instruction and class discussion approach, some students may need to become involved in an activity that involves worksheets or filmstrips covering the same subject in a different way.

Suggestions for development and use of correctives:

- Plan corrective activities in advance.
- Gear them to the learning objectives in your plan.
- Teach the same material that was covered in the group lesson.
- Change the instructional approach so that material is presented differently.
- Reteach with a small group using a different approach from the initial instruction. This is effective in all grades.

The correctives may be:

- alternative textbooks
- worksheets
- flashcards
- audio-visual materials
- learning games

(Individual correctives such as alternative textbooks and worksheets work best with older students.)

Listing Correctives

Some teachers have found it helpful to list specific correctives on Formative Test A next to each test item so that students can go directly to the correctives.

Time Period-Use correctives for a short period of time.

Many teachers find that because of time constraints one or two days can be spent on correctives. If necessary, give correctives for homework in addition to classwork.

Peer Tutoring for Students Who Work Well With Others

Plan for some students to do peer tutoring under your supervision.

WHAT DO STUDENTS WHO ACHIEVE MASTERY DO DURING THIS TIME?

Provide enrichment activities that are:

- an extension of the learning presented during the unit
- related to concepts covered in the unit or in previous learnings
- integrated with this subject but in another curriculum area
- creative for the student
- motivational so that the student is encouraged to achieve mastery on future formative tests

Some enrichment activities that Mastery Learning teachers have used are:

- in-depth research using library books, encyclopedias and other resource materials
- map making
- student made games
- creating crossword puzzles for other students to complete (using words learned in the unit)
- filmstrip making
- working on a class project
- illustrating
- individualized programs
    - kits
    - task cards with enrichment activities

WHAT CLASSROOM MANAGEMENT STRATEGIES ARE EFFECTIVE WHEN WORKING WORKING WITH INDIVIDUAL STUDENTS AND SMALL GROUPS?

Develop routines for:

- assessing mastery
- diagnosing incorrect answers

Students in the upper grades can participate in assessing mastery, diagnosing incorrect test items and locating correctives.

- Set up rules that are understood by all students.
- Compliment students when routines are followed successfully.
- Plan all correctives and enrichment activities in advance.
- Some teachers in the elementary grades have areas or centers in the classroom for corrective and enrichment activities. Students move to these areas where worksheets, learning games, kits and other individualized activities are set up for their use.

  These activities should be:

  - self-checking
  - self-directed

When working directly with a small group, here are some ideas that teachers have used:

- seat the students (in the group close to you in a circle, if possible).
- provide sufficient self-checking and self-directed enrichment activities that "free" you to work with the other group (provide an extra or bonus activity for students who finish early).

- reteach in a way that is different from the initial teaching (e.g., try visuals if they were not used in the whole class lesson)

What classroom strategies do you find effective when working with individual or small groups? List 3 strategies:

1. _____

2. _____

3. _____

HOW DO I DETERMINE STUDENTS' LEARNING FOLLOWING THE USE OF CORRECTIVES?

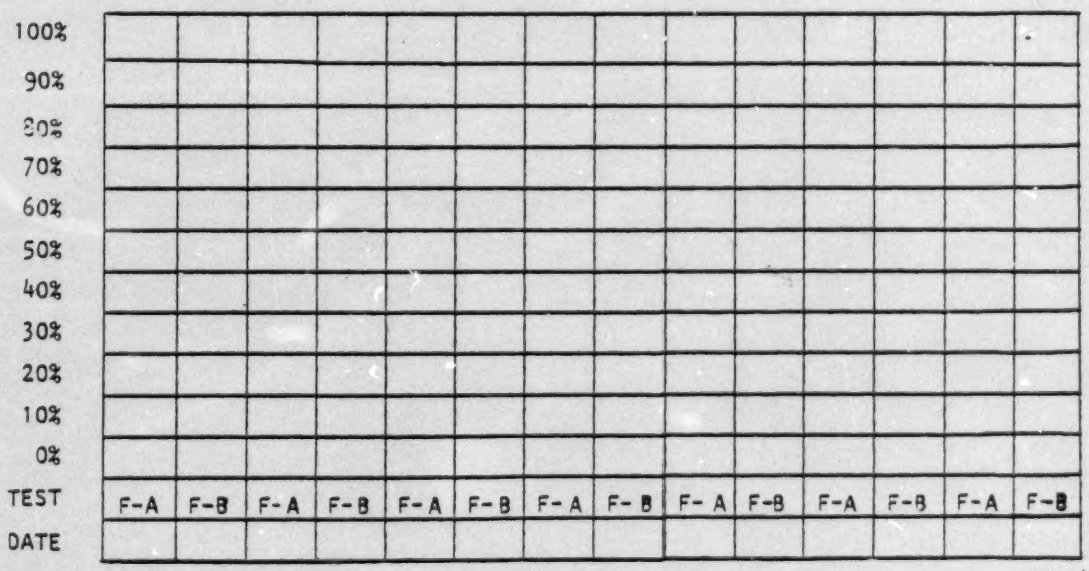
- Give formative test B to students who did not get mastery on the first test to determine learning of the concept after using additional activities.

- Mark the test using the same mastery standards as you did for the first test.

Some teachers on all grade levels graph the results of both tests so that students can trace their growth. Bar and line graphs give a visual representation of the scores on formative tests A and B.

Sample Bar Graph

My Mastery Graph **Name** _____



NOTE: F-A and F-B represent Formative Tests A and B.

HOW DO I MOTIVATE STUDENTS TO STUDY FOR FORMATIVE TEST A IF THEY KNOW THAT THEY HAVE A SECOND CHANCE?

- Provide enrichment activities that are challenging and worthwhile.
- Permit students to take formative test B if they achieve mastery and would like to try to "top" their score.
- Some teachers give students who get mastery on the first test "bonus" points.
- Others average the scores from formative tests A and B.
- These approaches leave room for the students who do not get "mastery" on the first test to get a second chance as well as offer the students who do get mastery several options.

There are many motivational strategies that teachers use to encourage student efforts. These techniques are not limited to Mastery Learning classes. Methods to motivate students, on any grade level, include a display of class goals and achievements such as:

Charts - a representation of class goals
Graphs - plot class average mastery levels attained
Banners - with class motto
Certificates - for students who show progress and for students who achieve mastery.
Signs - WE ARE A MASTERY LEARNING CLASS

(See sample chart and certificate on following page)

Sample Sign

WE ARE A MASTERY LEARNING CLASS

Sample Certificate

This is to certify that

_____

has achieved Mastery Learning

in his _____ class for the

_____ Marking Period _____

Date

WHAT ABOUT STUDENTS WHO STILL DO NOT "GET" MASTERY AFTER FORMATIVE TEST B?

- Provide some individual work for these students as you would with any learning strategy.
- Try smaller segments of learning, in future units, if most of the students do not get mastery.
- After formative test B, go on to the next unit of instruction, however, provide review of difficult concepts from previous unit.
- Reward efforts for improved learning even though students did not attain mastery of the unit of study. Many teachers have charts for extra effort and improvement.
- Check the students' study habits. The Mastery Learning approach provides a structured plan to improve study habits for slow learners that many fast learners already have. In addition, it provides an opportunity for fast learners to extend and enrich their learning experiences.

HOW CAN I ENCOURAGE PARENTAL SUPPORT OF THE PROGRAM?

Many Mastery Learning teachers find that informing parents about this program encourages understanding and support from home.

The following is a sample letter that can be adapted to your subject and grade level:

Sample Letter to Parents

Dear Parent:

This term your child is going to be involved in a program called "Mastery Learning". It is designed to provide methods to improve learning.

In this approach, the teacher instructs the class as usual. At the end of a short period (unit of study), your child will take a short quiz or test. This will show what was, or was not, learned. When needed, there will be correctives given for study in school and at home.

If the pupil did not achieve mastery on the first quiz, there will be a second test given after the correctives have been studied. Mastery is defined as approximately 80%, or better, on the first test.

If a child did well on the first quiz and achieved mastery, enrichment activities that extend learning, will be provided.

We encourage all pupils to make every effort to attain mastery at the end of the units of study. We also encourage your support of the program. If you have any questions, I will be happy to discuss Mastery Learning with you.

Sincerely,

_____

Parent's Signature

TABLE OF SPECIFICATIONS: A SUGGESTED MASTERY LEARNING PLAN

The table of specifications is a unit plan that is used by many Mastery Learning teachers. After deciding on the small segment of learning, draw up a table of specifications for each unit.

The table of specifications is a plan of unit objectives.

It is based on the:

- content elements which comprise the unit
- operations that you expect your students to exhibit

CONTENT ELEMENTS

Identify the content elements in the unit that you will want to include in your Table of Specification plans.

Content Elements

- Terms - new vocabulary words
- Facts - additional important information about content
- Concepts - concrete and/or abstract ideas
- Rules and Principles - the relationship among terms
- Procedures and Processes - steps that students must be able to perform

In preparing the Table of Specifications, select the content elements that apply to your unit of study.

INTELLECTUAL OPERATIONS

Determine what operations you expect your students to perform.

Decide whether you expect students to:

- know an element
- comprehend it
- apply it
- analyze it
- synthesize it
- evaluate it

TAXONOMY OF EDUCATIONAL OBJECTIVES

Refer to the Major Categories in the Cognitive Domain of the Taxonomy of Educational Objectives. (Bloom, 1956)

Knowledge - knowledge is defined as remembering previously learned material. This involves recall of terms and facts (literal skills)

Comprehension - comprehension is defined as the ability to grasp the meaning of the subject matter. This may involve translating material from one form to another (e.g., fractions to decimals), interpretation (explaining or summarizing) and predicting consequences or effects

Application - application refers to the ability to use learned material in new and concrete situations (e.g., using fractions in a recipe)

Analysis - analysis refers to the ability to conduct an analysis of elements or relationships (e.g., relationship between color in a painting and the emotion that it evokes)

Synthesis - Synthesis refers to the ability to put the parts together and form a new whole (e.g., put together a class play)

Evaluation - evaluation refers to the ability to make judgments regarding the value of material (e.g., play, novel, research report)

CONSTRUCTING THE TABLE OF SPECIFICATIONS

To construct a Table of Specifications, determine what you will teach and what your expectations are regarding student learnings.

Determine the:

- content elements
- operations
- educational objectives

Dr. Thomas R. Guskey has suggested the following workable unit plans or Tables of Specifications that many Mastery Learning teachers have used.

SAMPLES OF TABLES OF SPECIFICATIONS

- The headings for the Tables of Specifications vary according to the:
  - unit
  - grade level
  - learning objectives
  - intellectual operations
- The headings in the following Tables of Specifications reflect the objectives and operations that are included in the unit:
- SAMPLE HEADING

TABLE OF SPECIFICATIONS UNIT _____

TERMS	FACTS	RULES AND PRINCIPLES	PROCESSES AND PROCEDURES	TRANSLATION	APPLICATION

- SAMPLE HEADING

TABLE OF SPECIFICATIONS UNIT _____

TERMS	FACTS	CONCEPTS AND THEMES	TRANSLATIONS	APPLICATIONS	ANALYSIS, SYNTHESIS, AND EVALUATION

Some Suggestions

- Adapt the Table of Specifications to the subject matter. (e.g., when teaching mathematics, you the column under "evaluation").
- Gear the test items in formative tests A and B to the Table of Specifications so that you indicate, on the test, the specific content elements, operations and/or educational objectives. (see sample units).
- The heading for the Table of Specifications varies among Mastery Learning teachers.
- If you plan to go beyond application, include analysis, synthesis, and/or evaluation in the heading. Do you plan to teach "concepts" in this unit? If so, include it in the Table of Specifications.
- If you are teaching in a subject area that is all application (such as industrial arts), this would be reflected in the "application" column.
- The Table of Specifications is your plan. It should reflect your teaching objectives rather than become an obstacle to doing Mastery Learning.

SAMPLE MASTERY LEARNING UNITS

The Table of Specifications in the following Mastery Learning units serve as a plan for teaching the units. The test items for Formative Tests A and B are planned in advance, and are placed on the Tables, to identify the objectives and operations. The correctives and enrichment activities in the units provide for follow-up instruction in small groups.

You are ready to begin to plan and prepare your Mastery Learning materials, motivate your students and begin Mastery Learning in your classroom.

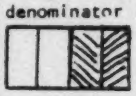
Finally, while time for planning additional activities is needed, many Mastery Learning teachers and students find that the additional learning is the reward for their extra time and effort.

A MASTERY LEARNING UNIT

USE AND MEANING OF FRACTIONAL NUMBERS

Level: Elementary
Grades 4-6

TABLE OF SPECIFICATIONS

TERMS	FACTS	RULES AND PRINCIPLES	PROCESSES & PROCEDURES	TRANSLATION	APPLICATION
			Move from concrete to semi-abstract to abstract.		
numerator	shaded area = 2/4 2 represents numerator 4 represents denominator	Numerator shows what part of the whole is represented.	Introduce concrete objects and divide into fractional parts. Show how numerator is part of the whole. Show how denominator would represent into how many parts whole is divided.	Rename fractions that are equivalant. Use fractions in problems.	Pupils use recipes calling for fractional parts of ingredients.
denominator		Denominator shows into how many parts whole is divided.	Move to diagrams. Divide into fractional parts and name numerator/ denominator.		
	repeat for halves, thirds and fourths.		Introduce abstract form for fractional parts and name numerator/denominator.		

TEST ITEMS
Use and Meaning of Fractional Numbers

TABLE OF SPECIFICATIONS

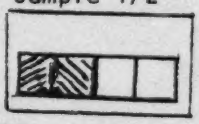
TERMS	FACTS	RULES AND PRINCIPLES	PROCESSES & PROCEDURES	TRANSLATION	APPLICATION
k	a b c	l		d e f g h i j k l m n o p q r s t	

USE AND MEANING OF FRACTIONAL NUMBERS

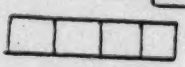
Formative Test A

Shade in the area for each fraction

Sample 1/2



a) 1/4



b) 3/4

c) 2/4

Fill in the following boxes /___/ with one of these choices. (>, <, =)

d) 1/2 /___/ 1/4

e) 3/4 /___/ 1/2

f) 1/4 /___/ 3/12

g) 1/3 /___/ 3/4

Formative Test A (continued)

Fill in the following sentences with the correct number:

h) In the fraction 2/3, the number _____ is the numerator and the number _____ is the denominator.

i) In the fraction 3/4, the number _____ shows into how many parts the whole is divided.

j) John ate 2/8 of a pizza. The pizza was cut into _____ pieces.

k) Susan cut her cake into 5 pieces. She gave out 4 pieces of cake. The fraction _____ represents how many pieces of cake were given out.

l) Steven read 4/30 of the book. There are _____ pages in the book.

Formative Test A (continued)

Match Equivalent Fractions
Draw a line from column A to Column B

A	B
m) 3/4	4/6
n) 6/10	9/12
o) 2/3	3/5
p) 1/2	20/40

Rename each fraction
Put the answer in the box ☐

q) $3/4 = \frac{\square}{8}$

r) $4/10 = \frac{8}{\square}$

s) $1/2 = \frac{\square}{60}$

t) $7/8 = \frac{21}{\square}$

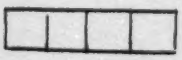
USE AND MEANING OF FRACTIONAL NUMBERS

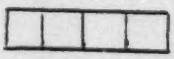
Formative Test B

Shade in the area
for each fraction

Sample:

1/2

a) 2/4 

b) 3/4 

c) 1/4

Fill in the following boxes ▱ with one of these choices.
(>, <, =)

d) 4/6 ▱ 2/3

e 1/2 ▱ 3/4

f) 2/4 ▱ 1/2

g) 2/8 ▱ 3/4

USE AND MEANING OF FRACTIONAL NUMBERS

Formative Test B (continued)

Fill in the following sentences with the correct number:

h) In the fraction 3/4, the number _____ is the numerator and the number _____ is the denominator.

i) In the fraction 2/3, the number _____ shows into how many parts the whole was divided.

j) Tom completed 6/15 of the test questions. There were _____ test questions.

k) The jar broke into 15 pieces. We glued together 7 pieces. The fraction _____ represents how much of the jar is fixed.

l) Sue rewrote 5/25 of her paper. There are _____ pages in her paper.

Formative Test B (continued)

Match Equivalent Fractions
Draw a line from Column A to Column B

A	B
m) 4/6	2/3
n) 9/12	1/2
o) 2/30	3/4
p) 7/14	1/15

Rename each fraction
Put the answer in the box ☐

q) $7/14 = \frac{\square}{2}$

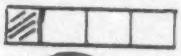
s) $9/12 = \frac{\square}{4}$

r) $6/30 = \frac{1}{\square}$

t) $14/21 = \frac{2}{\square}$

USE AND MEANING OF FRACTIONAL NUMBERS

Answer Sheet

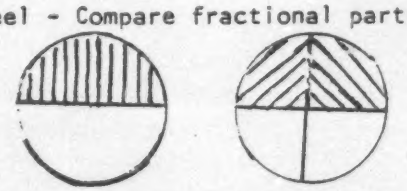
Question	Formative Test A	Formative Test B
a		
b		
c		
d	>	=
e	>	<
f	=	=
g	<	<
h	2, 3	3, 4
i	4	3
j	8	15
k	4/5	7/15
l	30	25
m	3/4 - 9/12	4/6 - 2/3
n	6/10 - 3/5	9/12 - 3/4
o	2/3 - 4/6	2/30 - 1/15
p	1/2 - 20/40	7/14 - 1/2
q	6	1
r	20	5
s	30	3
t	24	3

USE AND MEANING OF FRACTIONAL NUMBERS

Correctives:

1. Small Group Instruction.
   a. Review - Use concrete objects. Have pupils divide objects into fractional parts.
   b. Label each object with abstract fractional form.
   c. Find the larger part.
   d. Find the smaller part.
   e. Find parts that are the same size.

2. Peer Tutoring
   a. Fraction Wheel - Compare fractional parts of the wheel.



3. Individualized Work
   a. Worksheet - Review of fractional parts.

USE AND MEANING OF FRACTIONAL NUMBERS

Enrichment Activities:

1. Create a fraction game

   Instructions:

   Create a fraction game that can be used by your classmates. You may work alone or with someone else. This game will become part of a math game booklet. Each game should have the following:

   1. Directions
   2. Game Sheet
   3. Answers

2. Find one of the recipes in the cooking area marked "Recipe Box."

   On an index card in the box in the cooking area write another recipe, but this time plan the recipe for 3/4 of the amount of people using the same ingredients.

NOTE: The enrichment activities require the student to be able to translate and apply the terms, facts, rules, principles, procedures and processes learned in the unit.

USE AND MEANING OF FRACTIONAL NUMBERS

Summative Test Items

Rename each of the following in three ways: Fill in the boxes.

a) $3/4 = \frac{\square}{8} = \frac{9}{\square} = \frac{\square}{16}$

b) $5/6 = \frac{10}{\square} = \frac{\square}{18} = \frac{20}{\square}$

c) $2/3 = \frac{4}{\square} = \frac{\square}{9} = \frac{8}{\square}$

Circle the largest fractional part.

d) 1/2 2/3 2/40

Circle the smallest fractional part.

e) 10/ 15 1/3 2/4

Answer Key

a) 6, 12, 12

b) 12, 15, 24.

c) 6, 6, 12

d) 2/3

4) 1/3

A MASTERY LEARNING UNIT IN MATH AND SOCIAL STUDIES

ANCIENT EGYPTIAN NUMERATION SYSTEM

This unit can be adapted to: Elementary (Middle and Upper Grades), Junior High School and High School Levels

TABLE OF SPECIFICATIONS

Ancient Egyptian Numeration System

TERMS	FACTS	RULES AND PRINCIPLES	PROCESSES & PROCEDURES	TRANSLATION	APPLICATION
Numeration Tally Heel Bone Coil of Rope Lotus Flower Bent Stick Fish Astonished Man Hindu-Arabic Ancient Egyptian	1. There are seven basic symbols in ancient Egyptian numeration system. 2. Each symbol names a power of 10. 3. No number greater than 9,999,999 can be named in the ancient Egyptian system, since there is no symbol for ten million.	1. Multiples of each power of 10 are noted by repetition. (In contrast, the Hindu-Arabic system uses one of the basic digits in a particular place in order to name a multiple of the power of 10). Therefore, there is no place value in the ancient Egyptian numeration system.	1. Count using tally marks. 2. Count more than 100 objects by means of tally marks. 3. Use a slash mark across 9 previous tally marks to indicate a set with ten members. 4. When sufficient number of these sets of marks have been obtained, use "heel bone" of ancient Egyptians to replace each set. 5. Use ten heel bones and replace with coil of rope. 6. Continue process until repeated with "astonished man."	1. Use a combination of more than one symbol. 2. Rename in Hindu-Arabic numerals going from ancient Egyptian to Hindu-Arabic.	1. Pretend to be an ancient Egyptian in a market. "Buy" ten items. Write the purchase price of the ten items in a list. Add the list using ancient Egyptian symbols. Now, convert the list to the Hindu-Arabic number system. Check to see if the addition in both lists match.

ANCIENT EGYPTIAN NUMERATION SYSTEM

Test Items

TABLE OF SPECIFICATIONS

TERMS	FACTS	RULES AND PRINCIPLES	PROCESSES & PROCEDURES	TRANSLATION	APPLICATION
	a b c d e			f g h i	j k l m n o p q r s t

ANCIENT EGYPTIAN NUMERATION SYSTEM

Ancient Egyptian Symbol	Name of Egyptian Symbol	Hindu-Arabic Symbol
	tally	1
	heel bone	10
	coil of rope	100
	lotus flower	1,000
	bent stick	10,000
	fish	100,000
	astonished man	1,000,000

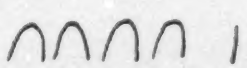
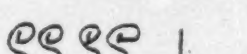
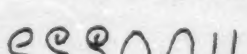
ANCIENT EGYPTIAN NUMERATION SYSTEM

Formative Test A

Circle the Correct Answer

Ancient Egyptian Symbol		Circle the Answer that Represents the Egyptian Symbol			
a)		5	10	100	1,000
b)		1,000	10,000	500	510
c)		1,000	25	100,000	100
d)		1	100	10	1,000
e)		10	1	100	10,000

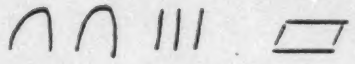
Circle the Correct Answer

f)	 =	241	41	44	501
g)	 =	104	50	401	5
h)	 =	230	322	200	700
i)	=	20,010	30,011	31	30,010

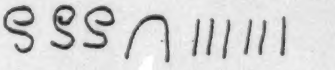
ANCIENT EGYPTIAN NUMERATION SYSTEM

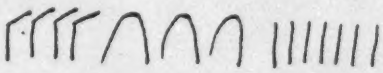
Formative Test A (continued)

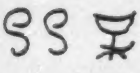
Fill in the Following Boxes ▱
With One of These Choices: (> , < , =)

j)  ▱ 23

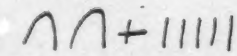
k) ▱

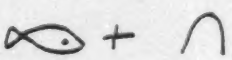
l) 220 ▱ 

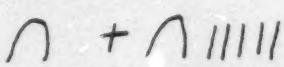
m) ▱ 

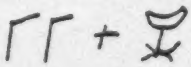
n)  ▱

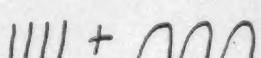
Add the Following Ancient Egyptian Symbols.
Change the Answer to the Hindu-Arabic Numeral.
Put the Answer in the Box.

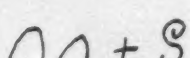
o)  = ▱

p)  = ▱

q)  = ▱

r)  = ▱

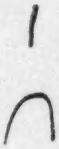
s)  = ▱

t)  = ▱

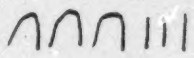
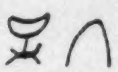
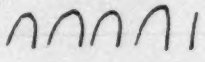
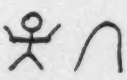
ANCIENT EGYPTIAN NUMERATION SYSTEM

Formative Test B

Circle the Correct Answer

Ancient Egyptian Symbol		Circle the Answer that Represents the Number			
a)		10	1	5	100
b)		1	10	100	1,000
c)		100,000	100	10	1,000
d)		100	10,000	10	1
e)		1	10	100	1,000,000

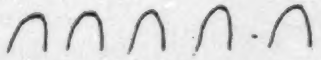
Circle the Correct Answer

f)		=	13	33	103	300
g)		=	100,010	1,000	1,010	110
h)		=	50	41	110	500
i)		=	100,010	110	1,000,010	1,010

ANCIENT EGYPTIAN NUMERATION SYSTEM

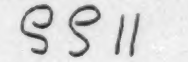
Formative Test B (continued)

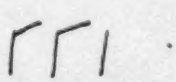
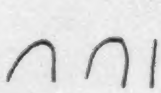
Fill in the Following Boxes ▱
With One of These Choices: (>, <, =)

j)  ▱ 25

k) 110 ▱

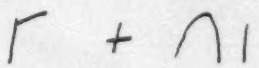
l) ▱ 22

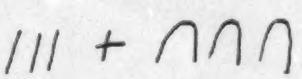
m)  ▱ 200

n)  ▱ 

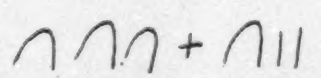
Add the Following Ancient Egyptian Symbols.
Change the Answer to the Hindu-Arabic Numeral.
Put the Answer in the Box.

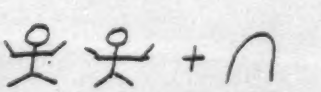
o) = ▱

p)  = ▱

q)  = ▱

r) = ▱

s)  = ▱

t)  = ▱

ANCIENT EGYPTIAN NUMERATION SYSTEM

Formative Test Answer Key

Question	Formative Test A	Formative Test B
a	10	1
b	10,000	10
c	100,000	100,000
d	100	100
e	1	1,000,000
f	41	33
g	401	1,010
h	322	41
i	30,010	1,000,010
j	=	>
k	>	<
l	<	=
m	>	>
n	<	>
o	25	33
p	100,010	10,011
q	25	33
r	21,000	200,000
s	34	42
t	120	2,000,010

ANCIENT EGYPTIAN NUMERATION SYSTEM

Correctives:

1. Small Group Instruction

   a. Review - Ancient Egyptian symbols on chart with students in a small group.

2. Individualized Work

   a. Worksheet - Match ancient Egyptian symbol with Hindu-Arabic numeral.

   b. Chart - Ancient Egyptian symbols. Fill in missing Hindu-Arabic numerals.

3. Peer Tutoring

   a. Add ancient Egyptian symbols. Convert to Hindu-Arabic numerals.

4. Homework

   a. Fill in worksheet with Hindu-Arabic numerals. Draw matching ancient Egyptian symbol.

NOTE: Correctives include activities using several learning modalities that vary from initial instruction:

Students are involved in:

- Small group interaction
- Writing
- Individualized instruction (peer tutoring)
- Drawing (ancient Egyptian symbols)

ANCIENT EGYPTIAN NUMERATION SYSTEM

Enrichment Activities - Elementary and Junior High School:

1. Using the facts that you have learned, choose one of the following tasks:
   a. Experiment with subtraction using the ancient Egyptian symbols.
   b. Make up your own numeration system. Make up an answer key. Choose a partner in your group to figure out your system.

2. a. Fill in the cross number puzzle in ancient Egyptian.
   b. Make up a cross number puzzle in ancient Egyptian. Prepare a separate answer puzzle sheet. Choose a partner in your group to complete the puzzle.

Enrichment Activities - Junior High School and High School:

1a. Compare the ancient Egyptian number system to the Hindu-Arabic system. In your comparisons, evaluate the ancient Egyptian number system in terms of the time needed to compute using addition and subtraction.

2b. Trace the development of the Hindu-Arabic number system. Is there any evidence to indicate a connection with the ancient Egyptian system?

3. Describe what the ancient Egyptian market-place may have looked like. Describe the exchange of goods that took place and the way that transactions were counted.

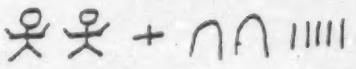
NOTE:

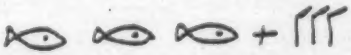
- The enrichment activities are:
  - challenging
  - self-directed
  - self-checking
- The activities free the teacher to work with the group that needs correctives.
- The activities involve intellectual operations that require the students to:
  - know an element
  - comprehend it
  - apply it
  - analyze it
  - synthesize it
  - evaluate it
- The activities involve the following content elements and educational objectives that were included in the unit Table of Specifications:
  - Terms
  - Facts
  - Rules and Principles
  - Procedures and Processes
  - Translation
  - Application

ANCIENT EGYPTIAN NUMERATION SYSTEM

Summative Test Items

Circle the Correct Answer

1)  = 2,000,030 250 1,125 2,000,025

2)  = 33 330,000 3,000 30,000

Answer Key

a) 2,000,025

b) 330,000

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